Bionomics and Distribution of the land leeches of Kumaon Hills, U.P.

BY

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(*with 5 text-figures*)

Introduction

Land leeches are reported from almost all the hill areas in India where they swarm in an incredible profusion, and prove a very harmful pest to animals and mankind by sucking their blood. Very little accurate information concerning their activities is recorded. It is a well-known fact that they are very active during rainy weather but no one appears to know what actually becomes of them during the dry season, and their appearance immediately with the coming of rains, raises the question, 'Whence do they appear?'. Some believe that they lay eggs and die with the advent of dry season, and that those which reappear on its conclusion are a new generation. There is little literature on the subject.

Extensive field and laboratory observations were made for three continuous years, and it has been possible to gather first-hand information about several hitherto unknown and doubtful aspects of land leeches, which are recorded here.

Although several species of land leeches, commonly found in Kumaon Hills, were collected, the observations recorded here are based primarily on the behaviour of two very common species, *Haemadipsa zeylanica agilis*, and *Haemadipsa montana*, which should hold good for other varieties of land leeches elsewhere in India.

The Junior author owns an agricultural farm and also an apple orchard, in Kumaon and thus had the advantage of first hand knowledge, extending over several years, of the activities of land leeches throughout a calendar year. His valuable field observations of these creatures form subject matter of this paper.

Habit

At the advent of rains, leeches emerge from hibernation and begin to swarm to the upper limits of the hills. During rains they are found on almost all patches of land in oak forests and are especially abundant along the foot-paths frequented by cattle, wild animals, and man. They are also present in large numbers in grass pastures adjacent to oak forests, which are frequently visited by man and domestic animals.

Moore (1927) reports that *Haemadipsa sylvestria* from Assam, enters water voluntarily during dry season and swims actively. Contrary to this, the common leeches of Kumaon region *Haemadipsa zeylanica agilis*, and *Haemadipsa montana*, do not enter streams during short dry spells during the monsoon and even in the prolonged drought period of hibernation. Their avoidance of wet and flooded areas of the forests suggests that they dislike such habitats.

In the early part of monsoon, after the first few showers, leeches are very active but when incessant rains set in, they crawl under dead oak leaves on the ground. During bright sun-shine also they hide under leaves and stones and resume their activities when it is cloudy and humid. They remain active during night, but become much more alert when rays of the early morning sun fall on them. Leeches are seen either standing erect on their posterior suckers, swaying all around, or moving on the ground. When erect they appear like small twigs among the layers of dry oak leaves. Leeches living in forests and swamps, may climb on leaves and branches, and wait until a suitable mammalian prey present itself.

After a full blood-meal, they crawl beneath the leaves or under some suitable cover and remain in a sluggish condition for a number of days, but those that do not get an opportunity of procuring a meal come out at the slightest disturbance.

Wounds caused by their bites generally heal up within a few days, though land leeches have the peculiar habit of biting repeatedly at the same spot which sometime causes pathological complications. Sometimes the bite becomes an open sore, probably due to secondary infection. Landleeches attack all the warm-blooded animals but find difficulty in getting blood from animals with thick fur covering. Some bare portion of the body of animals is selected for this purpose.

Habitat

Haemadipsa zeylanica agilis and *Haemadipsa montana*, along with other land leeches are found abundantly between heights 5000 and 6000 ft. and range from ravines as low as 3000 ft. to hill-tops ranging up to 11,000 ft. above sea level. Oak forests which cover the major

part of the hill-tops of Kumaon, provide the most suitable habitat. But in late rainy season it is not uncommon to find them even in the

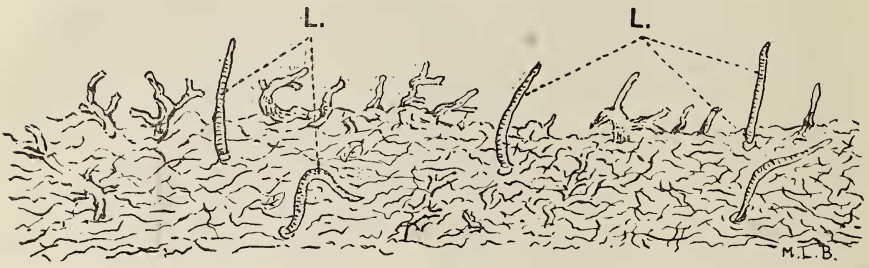

Fig. 1. A few leeches camouflaged in their natural habitat. L. leeches.

pine forest, orchards, grassy meadows, and even in cultivated paddy fields, adjacent to the oak forests. It has been noticed that they are totally absent from some parts of the forests, particularly forests on the southern aspects of the hills and heavily colonise some and are scanty in other parts of the northern aspect of the hill.

Leeches are primarily aquatic and have secondarily acquired life on land. Humidity remains their prime requirement for survival. The role of temperature is also significant as they are limited to a temperature between 10° and 25°C.

The extensive forests in the second and third climatic belt of Kumaon region, provide suitable conditions to these creatures. At elevations between 5000 and 11,000 ft. the rains during the monsoon are fairly heavy. In the second belt the average rainfall is 70″ to 120″, while in the third belt it is 40″ to 80″, of which eighty per cent falls during the rainy season. The forests are dense and evergreen on the northern face of the hill and thin on the southern side. The oak forests have luxuriant under-growth and the trees are draped in a rich epiphytic flora of ferns, mosses, and lichens. Other common trees in the oak forests are 'Brunch' (*Rhododendron*), 'Ringal' (*Arundinaria*), 'Kaphal' (*Myrica*), and a few species of *Berberis*, all with broad evergreen leaves.

The oak forests with this kind of luxuriant vegetation and with a rainfall of over 70″, has high humidity during the rainy season and even otherwise. The average maximum temperature does not rise above 26°C. These two major factors coupled with a few other attributes of the oak forests, such as the shade under the broad-leaved, evergreen trees help in maintaining moisture. The greater water retaining capacity keeps the valleys humid during the hibernation period. The carpet of dead oak leaves on the ground provides shelter during temporary dry spells and checks surface evaporation and the luxuriant under-growth that keeps the forest

humid and provides a substratum for their movements. All these provide ideal ecological conditions for leeches. An additional advantage is the fire resisting qualities of oak forests that have saved leeches from total eradication.

The density of leech population varies much in different parts of the forest, due to several factors that influence the habitat. Dense forests on the north facing slopes provide a much more suitable habitat than the forests on the southern side, which are very sunny and almost bare, comparatively warm, and less moist and sometimes quite dry. It is interesting to note that human agency has influenced to some extent the colonisation by leeches, and densely infested leech localities are always found near the grazing grounds and human habitation.

Leeches found in other places, like orchards, meadows, paddy fields and open patches of land during the rains, are actually migrants from the main oak forests. There is evidence to support the fact that they do not really emerge in these parts; that they migrate to all these localities after their emergence in the oak forests. They are seen in these parts quite late in the season and they also disappear early. Leeches do not permanently colonise these areas due to unfavourable conditions, particularly during the hibernation period.

During the rains, they are also found in the neighbouring xerophytic pine forests which have the same altitudinal range, but are really migrants from adjacent oak forests. Certain mixed type of forests, along with ravines which have a large number of oak trees, are very heavily colonised. Leeches have not successfully colonised pine forest because of xerophytic conditions, lack of undergrowth, the disagreeable and repelling smell of resin, and the absence of suitable shelter among the needle-shaped pine leaves. To all these may be added prevalence of fire.

Although between 7000 and 9000 ft. altitude there are different types of forests in the same altitudinal range and with almost similar conditions of shade and temperature as those in oak forests, it is surprising to note that leeches do not inhabit these forests. Viewing the general conditions of these forests of Blue pine (*Pinus excelsa*, 6000 ft. to 8000 ft.); Spruce (*Picea norinda*, 7000 ft. to 9000 ft.); Cypress (*Cupressus torulosa*, 6500 ft. to 9500 ft.); and Deodar (*Cedrus deodara*, 8000 ft. to 10,000 ft.); it seems that the meagre rainfall (10″ to 40″), needle-shaped leaves, scarce under-growth and lack of hibernating grounds have completely checked the infestation of these forests.

Food

Land leeches are blood-sucking ectoparasites and they are remarkably adept at taking from the host very considerable quantity of blood

without being noticed. In natural conditions it has been observed that they feed infrequently but take large quantities of blood at one time, over ten times its own weight. Digestion and absorption are very slow processes, and it takes nearly 8 to 10 months to assimilate a full blood-meal.

Smythies (1953) raised the question, whether land leeches feed only on blood or could also subsist on other food materials, such as humus and plant-juices etc. Harrison (1953) believes that they feed exclusively on blood, and we fully endorse this view. Hungry leeches kept in cages, containing humus, oak leaves, succulent herbs, and a few common invertebrate forms (earthworms, some arthropods, and slugs etc.) that are commonly found in leech localities, remained untouched by leeches and they starved and did not survive. On the other hand leeches fed on blood grow well and survive up to the hibernation period. It has been possible to keep leeches for more than three years by providing them a single blood-meal every year, with suitable conditions of temperature and moisture.

It is a well established fact that leeches feed on blood and blood only, but the information regarding the favourite victim is very meagre and it is also not known whether all the leeches are able to procure at least a single blood-meal. They rely for their nourishment on their ability to make contact with vertebrate hosts capable of rapid movement. The common vertebrates inhabiting the forests of Kumaon, like Barking Deer (*Muntiacus muntjak*); Goral (*Nemorhaedus goral*); Sambar (*Cervus unicolor*); Rhesus Monkey (*Macaca mulatta*); Langur (*Presbytis entellus*); and Serow (*Capricornis sumatraensis*), are all attacked by leeches. Birds are not usually attacked. Some birds (Kaleej and Koklas pheasants) were shot in the leech-infested areas during the rainy season and a few leeches were found on their tarsus, but there were no signs of previous bites by leeches on any of the birds to indicate that they had frequent leech attacks.

A number of species of rats, and moles exist in the oak forests, which become their victim. But leeches kept with the common rat (*Rattus rattus*) in a cage in the laboratory, did not touch the rats.

Moore (1927) refers to a freshwater crab (*Potamon atkinsonianum*) as a specific host of the leech *Haemadipsa sylvestris*. The only large invertebrate slug (*Limax*), common in leech localities in Kumaon, is not attacked by these leeches.

Kinloch (1922) reported a leech attacking *Dryophis*, an arboreal species of snake, in a coffee plantation at Nelliampathy hills in south India.

Moore (1927) reports to have received specimens of land-leeches collected from the local frogs of Ceylon. A large number of toads

(*Bufo melanostictus*) very commonly seen in the same locality during the rainy season, were found free from leeches.

The present study of leech habitats and the wide range of victims they come across gives the impression that leeches do not get frequent opportunity of securing a meal. Large wild animals capable of rapid movement usually abandon heavily infested areas, while rodents with their dense fur-coat and birds on account of feathers do not offer much chance of a meal to leeches. We feel that domestic animals are the main source of their subsistence. It has been noticed that some wild animals and cattle are their primary victims. The colonisation of grazing lands, cattle tracks and the areas near human habitat, support the above view. On cattle that daily visit or only pass through these areas for grazing, it is a common sight to find at least eight to ten leeches sticking in between their hooves and bare parts of the body, particularly the nasal and genital regions.

It has long been queried whether the entire leech population is able to secure a meal. In this connection it is worth noting that the reported abundance of leeches by previous workers appears to be an exaggeration. In fact the fear and annoyance caused by these agile creatures have probably led workers in the past to over-estimate their population. The same view has been expressed by Moore (1932) who made observations on land leeches in this country. Harrison (1953) made an attempt to give an approximate estimate of leech population. His figures seem quite reasonable but we feel that wild-stock alone, at least in the Kumaon, is not sufficient to provide meal to most of the leeches. During the present study an attempt was made to calculate the approximate density and leech population in different localities in Kumaon hills, and worked out as 4 leeches per square metre. According to this, a total land area of 10,000 square metres would have an approximate leech population of about 40,000 individuals. Considering the average number of leeches attacking per cattle (4 leeches to an animal) and number of cattle grazing in leech infested areas (100 animals a day); it could be estimated that most of the leech population is able to get at least one meal in an active season of approximately 100 days.

Copulation

Land leeches, like other members of the group, are hermaphrodites. Reciprocal cross-fertilization takes place by the union of two individuals. The process of copulation in land leeches was observed in nature by Leslie (1951) and Harrison (1953). Leeches usually copulate in the month of April and it has been possible to watch the process in field and also in the laboratory.

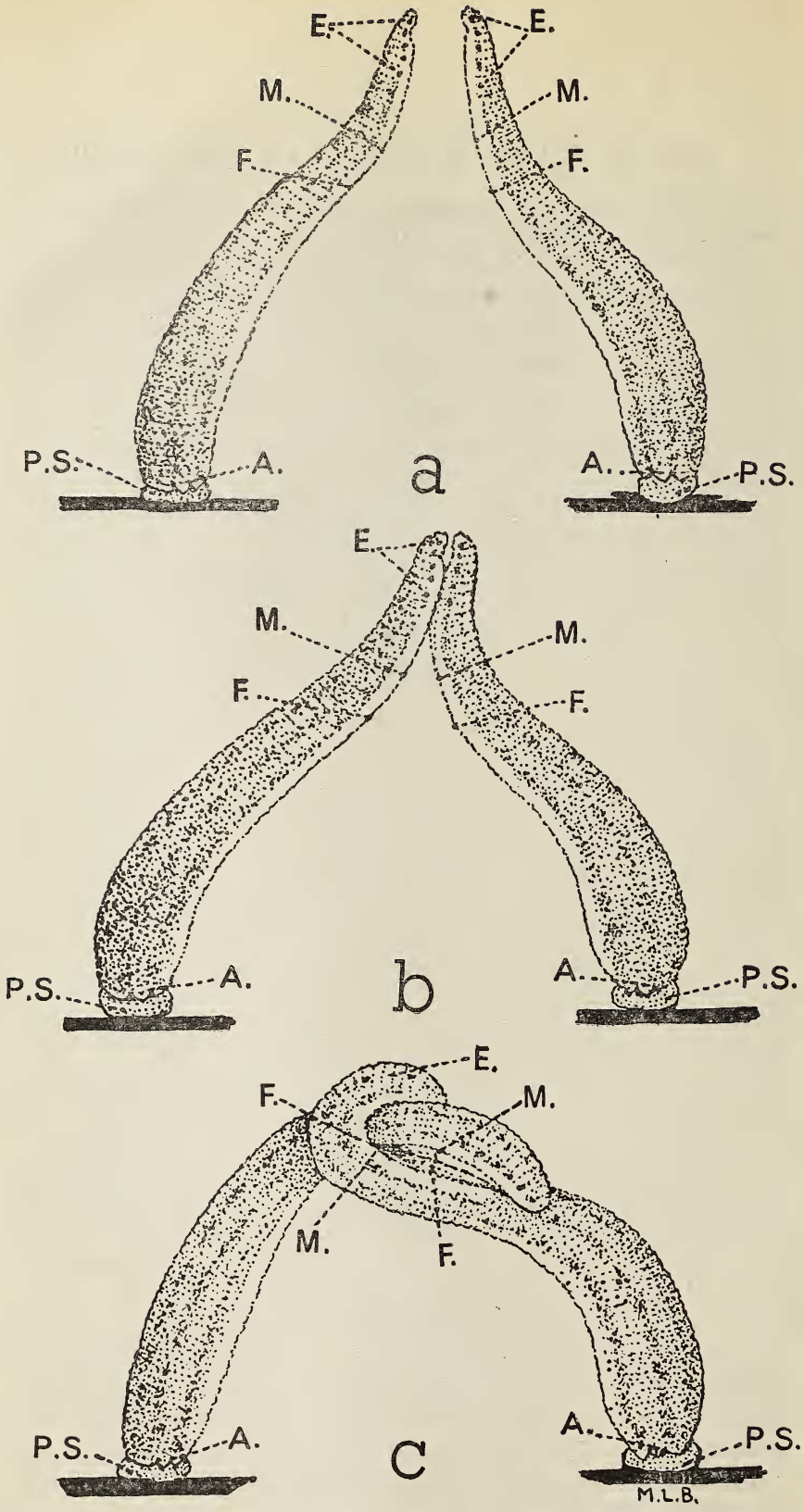

Fig. 2. Sketches showing different postures, leading to copulation. a. Pre-copulation posture, with the posterior suckers of both the leeches attached to the substratum, and body standing erect. b. Close contact of the pre-clitellar portions of the two worms. c. Copulating posture : anterior portion of one curves round the anterior portion of the other, entwined in a head to tail position. Both slightly raised from the ground in the form of an arc. The male genital pore of the one is opposed to the female aperture of the other and vice-versa. A. auricle; E. eyes ; F. female genital aperture ; M. male genital aperture ; P.S. posterior sucker.

Leeches move about in different directions, and when two full-grown leeches meet head to head for a short while, they fix their posterior suckers on to the substratum and sway their bodies till they touch each other. The act of swaying and a sort of embracing action of the two, taking place before the actual process of copulation was termed by Leslie as 'Dance' which lasts for a few minutes. Such casual contacts between the two leeches are not of much significance in the beginning as leeches often come close together, touch each other and separate. In cases where such meeting leads to actual copulation the animals after some preliminary muzzling establish close contact. With the posterior suckers firmly fixed to the substratum, the anterior portion, up to the clitellar region of one curves round the anterior portion of the other, in a head to tail position. The part of both that are in close contact get slightly raised from the ground and assume the shape of an arc. The ventral side particularly the clitellar region gets slightly flattened. In this posture the male genital pore of one is opposed to the female aperture of the other and vice-versa. Both remain in this position almost motionless for some time, except for a continuous slight swaying backwards and forwards. This is followed by alternate pressing movements of both leeches, by which the clitellar regions of both get further flattened and develop still closer contact. At this stage the male organs of both project, as was observed and recorded by Leslie, and transference of seminal fluid takes place in a reciprocal manner.

During the process of copulation a whitish jelly-like lubricant material, probably secretion of the prostate or more likely of the clitellar glands, is seen in between the surfaces of the two worms that are in close contact, which becomes more evident when they separate after the copulation. Soon after the process the posterior suckers get detached and the leeches start moving the usual way.

In several copulating individuals it has been possible to watch the entire process and to record the total period involved in the act. Beginning from their coming in close contact, to actual copulation and separation, the time involved ranges from 40 to 65 minutes. Leslie records 'Dance' for about 2 minutes and actual process lasting for one and a half minutes. Harrison's note on sexual behaviour of leeches, leading to copulation, and the figure given by him show the posture prior to actual copulation, which he observed lasting for an hour and a half. Actual copulation takes place only after the male orifices get opposed to the female apertures, a position not achieved in the figure given by Harrison, which depicts only close contact of the two worms. He therefore missed this important point in his observation.

Cocoon Formation

Leeches that have successfully mated lay cocoons, generally in the months of May and June and sometimes even in July. During these months the clitellar region (segments IX, X, and XI) becomes slightly depigmented owing to the presence of large number of epidermal clitellar glands, and it becomes slightly yellow in colour. The cocoon laying process is almost similar to that in other members of the group described by Khan (1912), Matthai (1921) and Bhatia in HIRUDINARIA (1941). Just before the actual process of cocoon laying, the leech becomes sluggish and settles down at some shady place, free from any kind of disturbance. A copious secretion of several layers of snow-white froth, secreted by the glands of clitellum, appears all round the clitellar region in the form of a girdle. During the formation of the frothy material the front portion of the leech, up to the clitellum, shows a slow rolling, as well as dorsoventral movement, while the post-clitellar portion of the body exhibits no movement. Formation of the frothy girdle takes about an hour. After that, large quantity of albumen, and fertilized ova extruded through the female generative aperture pass into the frothy girdle. By rhythmic movements, the leech withdraws the entire front portion. The plugs at the two poles of the cocoon are secreted by the prostomial glands, as stated by Bhatia (1939). Cocoons are generally laid in well protected shady places. The cocoon formation is a comparatively slow process lasting for about 5 to 6 hours. The froth on exposure to air hardens and forms an outer spongy layer with spacious air cavities in it. Like other leeches, land leech lays successive cocoons after an interval of about 4 days.

Cocoon

The cocoon is barrel-shaped and measures 8 to 12 mm in length and 6 to 9 mm in breadth. The cocoon-wall consists of two layers: an outer formed by the hardening of frothy secretion, and an inner chitinous layer. The froth, when fresh in the process of cocoon laying, is in several layers of large bubbles and during hardening process the bubbles unite and form hard partitions, and by pressure acquire a characteristic pentagonal shape. This layer protects the contents from minor shocks and from pressure of oak leaves and other objects under which the cocoons are generally laid. During rains and flooding of the area the air cavities provide buoyancy to the cocoon. The inner layer is quite hard, smooth and tough, and enclosed in it are a mass of albumen and fertilized ova. Both the layers are transparent.

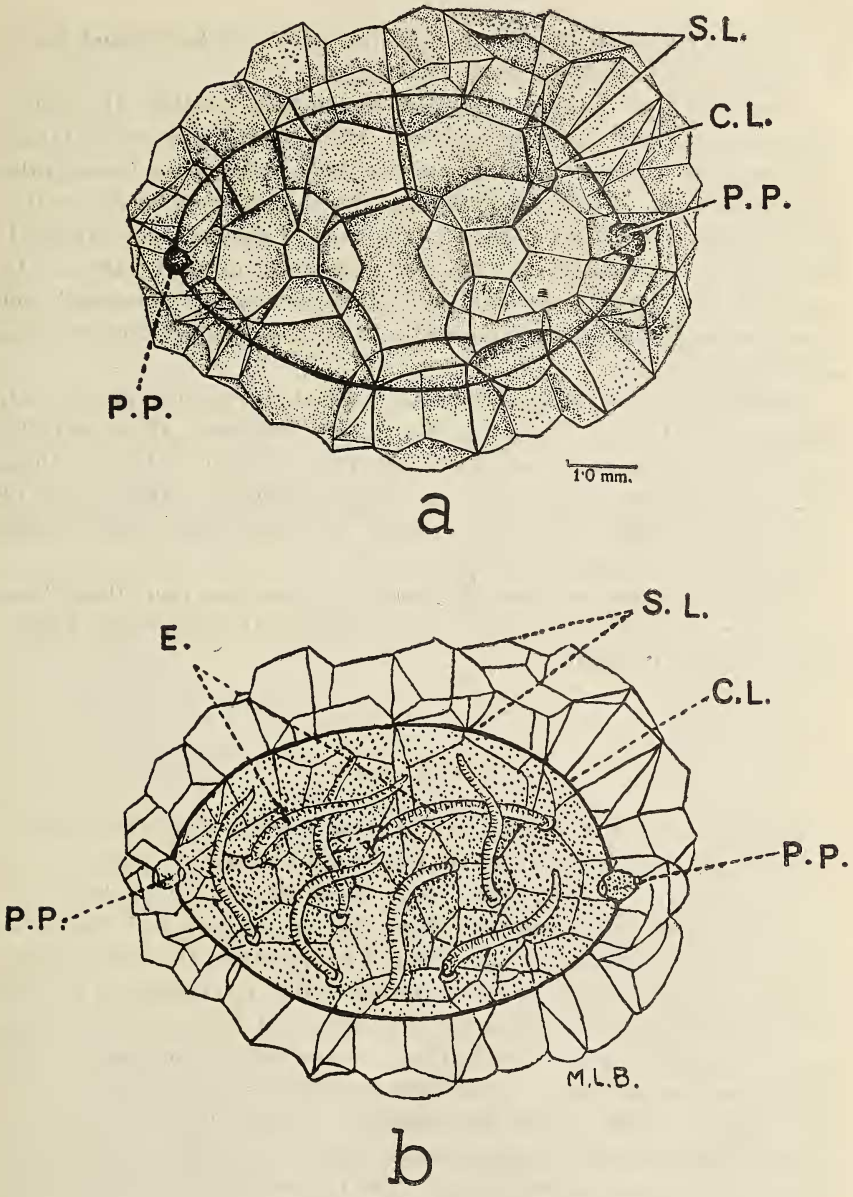

Fig. 3. Cocoon

a. Two days' old leech cocoon.

b. Longitudinal section of 18 days old, almost mature cocoon, showing 8 embryos inside it.

C.L. cuticular layer ; E. embryos inside the cocoon ; P.P. polar plugs at the two ends of the cocoon ; S.L. spongy layer.

Development

There is no larval stage in the life-history of the leech, and entire development is completed inside the cocoon.

Fertilized ova develop into embryos, which swallow the entire albumen contained inside the cocoon. After about 5 days of the laying of cocoon, the embryos are seen making slight movements, through the transparent cocoon wall. 8 or 9 days later the embryos become active inside the cocoon and in about 15 days most of the organs are formed, five pairs of pigmented eyes become prominent in each embryo. In about 20 days typical coloration and pigmentation are developed and development is almost complete and 6 to 9 young leeches emerge from each cocoon.

Freshly emerged young leeches are reddish brown in colour, each measures 5 to 10 mm. Soon after emergence they move about actively, and they remain active throughout the rainy season. Most of these succeed in getting a full meal, and attain maturity. At the close of rains they hibernate and on the onset of next rainy season they again become active, copulate, and lay cocoons.

It has been observed that land leeches survive for more than three years, but further observations are necessary to determine definite period of their life-span.

Life-Cycle

Observations on the life-cycle of land leeches show two distinct phases in their activities, an active phase and a dormant phase.

Active Phase: It generally starts from the month of June and lasts till the end of November. Since the appearance and disappearance of leeches depends on rainfall and temperature, the active phase extends mainly over the monsoon months (July to October). During this period they perform all essential functions of life namely feeding, growth, maturity and reproduction. Soon after emergence from cocoons they actively move about, and spread out over a large area and also migrate uphill. From the middle of July to the third week of August, their activities reach a climax, and by the end of September they start retreating to the valleys. By the middle of October they start hibernating and thus completely disappear.

Dormant Phase: The remaining six months (December to May) constitute the dormant phase or the hibernation period; but generally leeches disappear completely by November and reappear only by the end of June, thus extending the hibernation period to about eight months.

Migration

Migration or mass movement of land leeches has been a subject of much inquiry for a proper understanding of their ecology and biology.

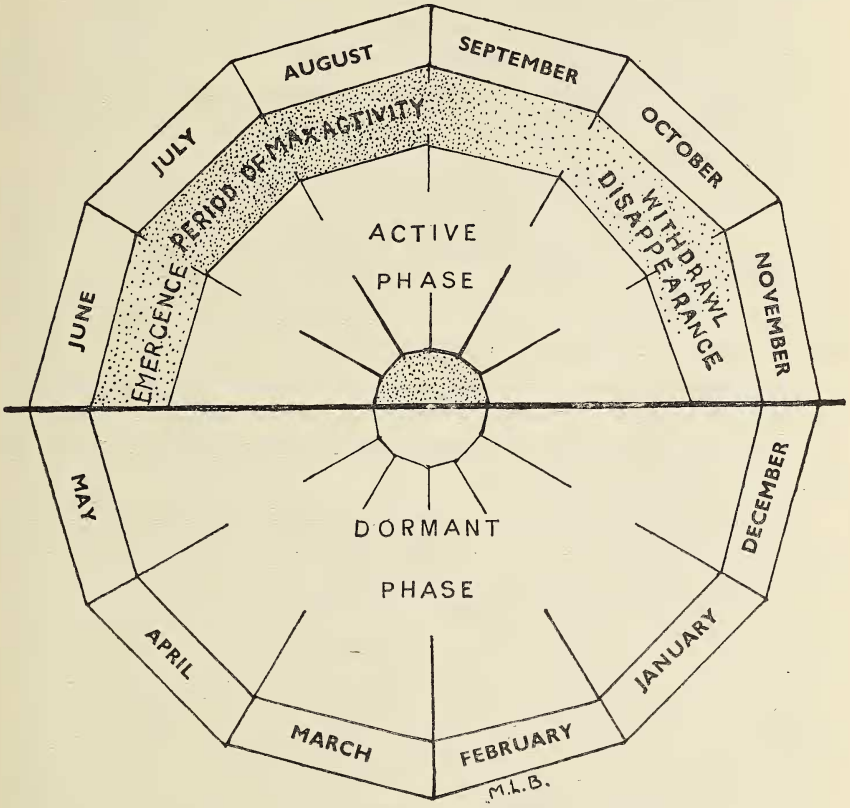

Fig. 4. Diagrammatic representation of the life-cycle of land leeches.

Among annelids the swarming of marine Polychaete worms is a phenomenon correlated with reproduction. In Oligochaeta and Hirudinea such examples are rare.

Moore (1932) has hinted on the seasonal migration in *Haemadipsa sylvestris* and *Haemadipsa zeylanica montivindicis*. In the latter species he describes an altitudinal migration also. Richardson (1942) has reported migratory behaviour in various species of freshwater leeches. In case of *Haemopis marmoratis*, a scavenger freshwater leech, he observed uni-directional advance of half a mile or even more and in *Glossiphonia complanata* he observed a habit akin to swarming.

Land leeches hibernate in valleys during the months November to May. On the advent of the rainy season they emerge and lead an active life, as mentioned earlier, in the humid oak forests of the hills.

The first emergence of leeches as already stated, is in the first week of June, by the sides of dry water courses or nullahs, soon after heavy shower of rain.

The bulk of the population of leeches that emerge at this time consists of leeches of appreciable size, small or even medium size leeches are rarely found at this period. After more rain they become very active and spread throughout the valley, which is still dry. By the middle of June rains become quite a regular feature with frequent heavy showers. Leeches, then, start spreading up towards the northern slopes.

Continuous rain all over the oak forest creates humid and moist conditions sufficient to provide moisture after a prolonged dry spell. The presence of widespread humidity initiates leech migration. By this time the number of leeches is as large as four to six per metre, and medium-sized ones are more in number than the large adults. After about ten days of emergence leeches spread nearly 100 metres up the northern slope. The upward movement during June depends on the weather conditions. If there is continuous rain, the advance is quicker, and their activities slacken to a great extent if there is a prolonged dry spell.

The month of July generally experiences incessant rains and activities of leeches increase in this period. By the second week they are found all over the summit, the cultivated fields and grasslands near the top of the hill, and this is the time when they prove a great menace. A study of the leech population in the middle of July reveals that at the top of the hill leeches of large size, and in the middle region both large and medium-sized are present in considerable number. Freshly emerged young ones form the primary leech population in the valley, though some are seen in the middle region also. By this time large number of cocoons hatch resulting in tremendous increase in the population stock of young leeches in the valley.

By the end of July the number of young ones, in the middle region of the hill, exceeds that in the valley. This is probably due to the emergence of large number of leeches from the cocoons, laid by the migrating leeches in the middle zone and migration of fresh stock of young ones from the valley upwards in search of a meal.

Freshly emerged stock of young leeches reaches the top of the hill by the second week of August and they are most active in their attack on animals and also human population. Observations indicate that from the 2nd week of July to 3rd week of August, the activities of leeches remain at their peak, and as such this period could be regarded as the ' Peak period of activity '. During this period even the xerophytic pine forests are quite moist and leeches are seen advancing to all these places. In such cases the migration is altitudinal, horizontal and even

downward. In fact during this period leeches migrate indiscriminately and spread to all possible directions in search of food. In oak forests they start moving upwards from the very beginning and show definite upward trend of migration, much more on the northern slope of the hill. The southern slope which is mostly covered by pine forests, the intervening areas between the xerophytic pines and the evergreen oak forests, are comparatively exposed to sun and are warm and dry. Hence the movement of leeches through such areas is practically impossible till heavy and continuous rains set in.

By the third week of August a downward migration commences, as indicated by the decline of their population at the summit; to such an extent that in the fourth week of August they withdraw altogether from the top of hills and appear to concentrate in the middle region of the hills. It is interesting to note their complete absence from the valley at this time of the season.

Till the middle of September leeches are in great abundance in the middle region but towards the end of September the entire stock, consisting of the adults, medium-sized and the young individuals, get confined to an area of about 80 to 100 metres above the valley.

By the first week of October further descent occurs and they are found very near the valley. At this time they are very sluggish, hide under oak leaves and come out only when induced by disturbances or some sort of vibrations in the surrounding objects. By the second week they disappear from the entire hill and only a few stray specimens are seen up to about 40 ft. above the nullah in the valley. After a few days they disappear altogether.

Thus it is observed that with the advent of rains, leeches emerge in the valley and migrate upwards to half a mile distance. At the close of rainy season they return to similar areas and hibernate till the next rainy season.

Causes of Migration

The region of the valley provides enough moisture to leeches during dry months of winter and summer and the onset of rainy season not only provides favourable conditions for them to emerge, but also moistens the herbage at heights. Leeches emerge just after hibernation and the newly hatched young stock at the valley needs a meal. The herbage and oak leaves on the ground, shady and moist conditions on the northern slope of the hill, provide favourable conditions to them to move about and spread all over the area in search of food. At the close of rainy season the herbage on the heights dries up, therefore they begin to withdraw and migrate back toward the valley which is more moist and constitutes an ideal hibernating ground. Guiding factors for

migration are the moisture, temperature and food. The to-and-fro migratory habit of leeches seems to be induced by the combined effects of the following causes :

Upward Migration

(i) Overcrowding, and scanty food supply in the valley.

(ii) With an upward movement of the livestock there are better chances of procuring food uphill.

(iii) Favourable conditions of humidity, temperature, and suitable moving space uphill on the northern slope.

Downward Migration

(i) Decrease in humidity on the top of the hill.

(ii) Availability of favourable hibernating spots at the base of the hill.

Hibernation

It has been observed that land leeches suddenly appear with the first shower of rain, gradually increase in number in certain areas, where they prove a great menace and suddenly disappear when cold weather sets in. Much attention was drawn by the old age mystery of their sudden emergence and disappearance. Suggestions on their probable hibernation were made as surmises rather than on any kind of actual field study of the problem. Tennant (1861) expressed surprise on the complete disappearance of leeches during the dry season and their appearance immediately with the coming of rains. Whitman (1886) suggested that 'they merely seek shelter under stones, sticks etc. as they do all times when not actively moving about, and thus protected against complete drying, await favourable conditions of moisture'. But he denied completely the possibility of hibernation except for those which live above the level of the occasional frost and snow.

Landon (1905) believed that land leeches died with the advent of dry season and those which reappeared on its conclusion are a new generation. *Macrobdella decora*, an aquatic American leech, has been reported by Moore (1927) to live in dry ponds during summer. Bhatia (1941) observed the same in the leech *Hirudinaria*. Similarly a little advanced type of 'draught torpidity' has been described in *Ozobranchus* by Oka (1922). On the contrary laboratory observations during the present course of study show that land leeches, once they become dry, are unable to regain activity, as is common with all living forms.

Moore (1927) summing up the previous views comments that leeches probably pass through a condition resembling hibernation. Later

(Moore 1932) suggested that leeches may concentrate in the vicinity of water sources. Recently Smythies (1953) writes, ' in the tropics they are active all the year round, but in a monsoon climate they disappear entirely for about six months, during the dry cold winter. Do they get through this period in the form of eggs or by burrowing into the soil ?

Our present observations are in conformity with the view of Moore (1932) and it has been noticed during the course of our field study that:

(i) The first emergence of land leeches, on the onset of rains, is always at the base of the hill, by the sides of dry water channels or nullahs.

(ii) After their emergence they spread all over, generally more towards the upper limits of the hill, and remain active throughout the rains. At the close of rainy season they gradually migrate to the valley and commence vanishing in the similar regions from where they first emerged.

These observations hint at their possible hibernating grounds. A search of the valley in winter months (December and January) reveals that leeches do not hibernate under the layers of decaying oak leaves, sticks etc., as was suggested by Whitman, a possible abode of their hibernation. Instead, it has been found that they hibernate fairly deep down in soft soil. On digging a foot or more deep, below the earth surface and on turning the underground buried stones and pebbles in the vicinity of water channels, a large number of hibernating leeches were everytime obtained, attached to undersurface of the stones.

Observations made during the active phase of leeches suggest that like all other living beings, food, congenial temperature, and moisture, are the primary guiding factors in the life of land leeches. It has been noticed in the laboratory that they can withstand fairly low temperature. Moreover, the subsoil temperature in the valley does not fluctuate beyond a critical limit. Thus, only moisture appears to be the chief influencing factor during the hibernation period.

Several other hibernating places have been suggested by previous workers, i.e., areas by the sides of water streams which are very damp and flooded, but leeches have not been found from any such localities. They do not resort to aquatic habit of any kind during hibernation. It has been confirmed in laboratory that leeches kept partially submerged in water or very near water, do not feel comfortable and immediately try to escape. They do not survive long in water.

The areas in the valley are slightly different from the other parts of the hill slopes. There is always loose layer of coarse sand and pebbles on the surface, under which, there is a mixed layer of humus, clay and sand. Sand and pebbles are brought down from the slopes of hill during heavy rains. Leeches make their way in to the underground sand

and humus through crevices in the upper layer of pebbles. The overlying layer of sand and stones protect leeches from dessication.

The sub-soil in the valley retains moisture and remains damp all the year round and this kind of constant wet conditions are maintained by various factors. In addition to the occasional rains, there is constant occurrence of what may be called the 'sub-soil moisture'. The soil in the oak forests retains comparatively greater amount of rain water. After heavy showers in the rainy season, at the lower levels of the hill there arise underground streams in the form of springs, which become a constant source of water supply to the nullah or water stream flowing at the base of the valley. When these seasonal springs and nullahs dry up in winter and summer, water retained by the roots of the oak trees in the upper limits, percolates through the underground streamlets. The presence of such streamlets is easily revealed by the marshy conditions even in dry season, when digging to a depth of about $1\frac{1}{2}$ ft. in the region of the nullah. Such sub-soil moisture keeps the hibernating places moist throughout the dry season. The surface evaporation of the sub-soil moisture is further cut down by the presence of a large number of evergreen trees and thus chances of drying up of such places are meagre. The selection of such places for hibernating is obvious.

Hibernating Leeches

Hibernating leeches lie in a dormant, contracted, and emaciated condition, attached by both the suckers to the undersurface of stones and other objects. *Haemadipsa montana* remains slightly more dormant than *Haemadipsa zeylanica agilis*, and its brownish or yellowish colour harmonises well with the surroundings to such an extent that sometimes it becomes difficult to spot these out in their hibernating habitat.

The hibernating leeches observed have been generally of large size, some of median size, but none of small size.

Behaviour of Hibernating Leeches:

Hibernating leeches are very sluggish, and they shun light. They do not respond to human breath or even touch. On pressing hard they show slight activity and immediately try to wriggle away and again hide under some nearby object. When submitted to slightly higher temperature than what they have in their natural habitat, they become slightly active, but not as agile as during the rainy season. Such activity lasts only couple of minutes even when the higher temperature is maintained for some time. When both higher temperature and moisture are provided, they become more active than when only

temperature is raised. Leeches that become temporarily alert try to escape. They do not respond to light of low intensity, and they respond negatively to strong light. They do not show any tendency to stick to the skin, bite and suck blood.

Distribution in Kumaon

The abundance and ferocity of land leeches have been reported from different parts of India by several naturalists. Haeckel (1883), Hooker (1854), Semper (1863) and others: Moore (1927) casually reported the occurrence of land leeches in Nainital district. As has been mentioned earlier, land leeches are confined only to oak forests, in Kumaon region. A general survey of the climate and vegetation of different regional belts of Kumaon, assists in explaining the distribution of oak forests, which provide suitable habitat to leeches.

The entire Kumaon area may be divided into several climatic belts, running approximately north-west to south-east, parallel to the Himalayas. The division is mainly based on the total rainfall and its relative percentage in winter and monsoon seasons.

I. A regional belt, the 'Sub-Himalayan tract', includes the area running along the foot-hills and consists of Bhaber and Tarai. Rains during monsoon are heavy, 50″ to 70″, and there are extensive forests of Sissu (*Dalbergia sissoo*), Khair (*Acacia catechu*) and Jaman (*Eugenia jambolana*). The maximum average temperature does not fall below 26°C which acts as a major influencing factor for the total absence of leeches from this region.

II. The 'outer hill range' stretches from the base of foot-hills in the region of Kotdwara, Kalagarh, Kathgodam, and Tanakpur, to the crest of the outermost range of the hills of Nainital. The hills rise, 1000 to 2000 ft. at the base and extend up to 4000 to 8000 ft. The general aspect of the hills is southern. Total rainfall ranges from 70″ to 120″ out of which 20% is during winter and 80% during the monsoon months. The dominant forests of Pine (*Pinus longifolia*) between 3000 to 7000 ft. are on the southern side. In pine forests due to xerophytic conditions and prevalence of frequent fire, the undergrowth is very scarce. On higher elevations and by the sides of ravines, the common oak (*Quercus incana*) replaces the pine. These forests are more common on the northern slopes, where the average maximum temperature does not rise beyond 26°C. The oak forests of Nainital district, Kilbery, China forest, Ratighat, Ramgarh, Gagar, Mukteshwar, Paharpani, Okhalkanda, Bhim-tal and Sat-tal etc. continue the upper boundary of this belt, are heavily infested with leeches.

III. Another regional belt, 'the central hill range' includes the vast area of mountainous country stretching to the outermost range of the

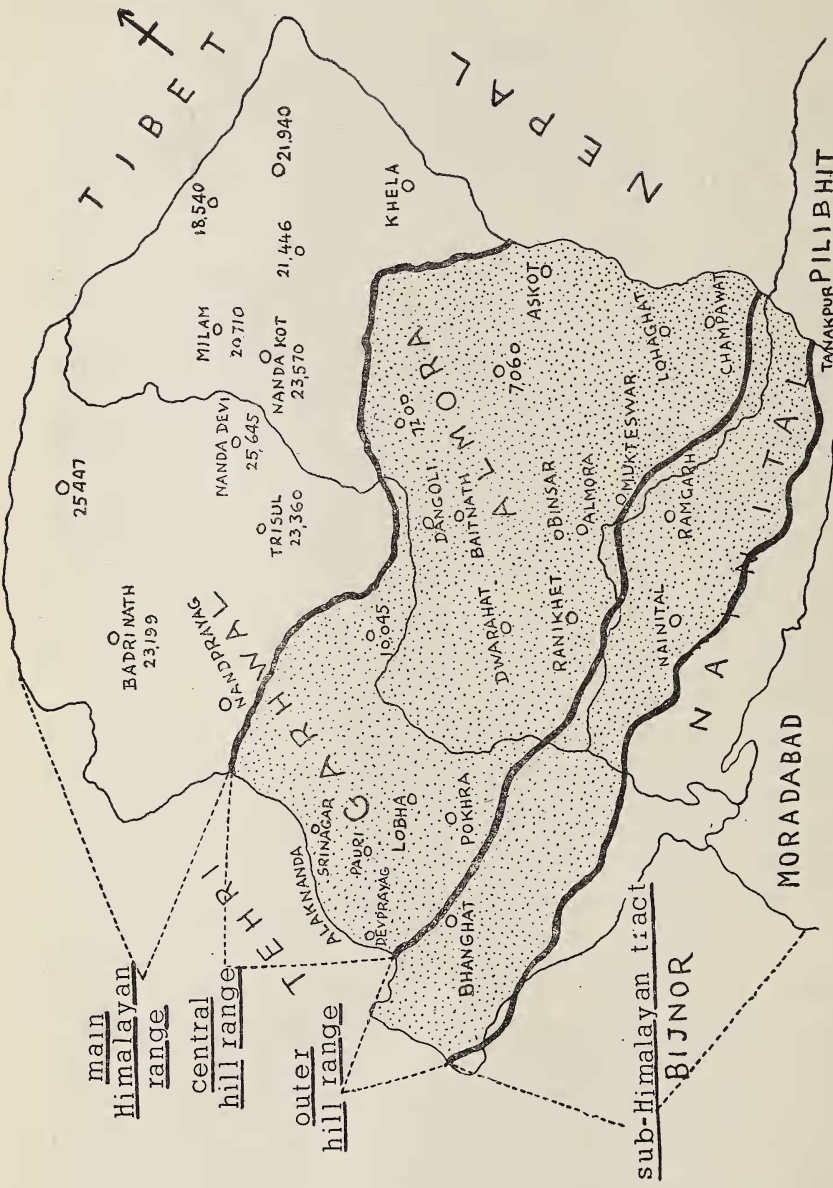

Fig. 5. Map of Kumaon, showing the topographical divisions and the distribution of land leeches in shaded regions.

main Himalayan peaks. The valleys of the river Sharda, Kosi, Ganga etc. lie at low level between the hills and the temperature is surprisingly high. Main intervening ridges range between 5000 and 10,000 ft. Annual rainfall varies from 40″ to 80″, 70% of which is during the monsoon season. Heaviest rain occurs in the prominent central ranges covered by oak forests (Dudotoli, Bhadkot, Binser, Gageshwar etc.). Most of the area between 3000 and 6000 ft. is covered by extensive pine forests, which is replaced by oak above 6000 ft.

IV. In the main Himalayan range, rainfall is 10″ to 40″ in monsoon, and snow during winter. Banj oak (*Quercus incana*) is commonly found between 6000 and 8000 ft. height but in damp ravines it is represented down to 3000 ft. in the Chir zone. Moru oak (*Quercus dilatata*) is found between 6500 and 9000 ft. and the Kharsu oak (*Quercus semicarpifolia*), between 7500 and 11,500 ft. All these forests are thinly or heavily infested by land leeches. In the upper limits of the Kharsu zone, leeches are very rare. It is possible that on the highest regions of the Kharsu zone which extends up to 11,500 ft. they are absent because of extreme cold.

Some of the heavily infested places in this belt are the oak forests of Shyahi Devi, Sittakhet, Jalna, Mornauli, Debidhura, Panwanaula, Binsar, Jageshwar, Dholchina, Dhakuri, Loharkhet, Kapkot, Attigaon, Munsayari, Kalamuni, Tejam, Karmi, Kanda, Gwaldom, Kaushain, Ranikhet, Dunagiri, etc. in Almora District, and Dharchula, Chandak, Lohaghat, Champawat, Agar, Chhera, Kalsinkatia in Pithoragarh district.

In Garhwal district, Tehsil Deoprayag and Patti Barmabanger are heavily infested and Patti-Sora, Hindab, Silgarh and Mandar are thinly infested.

References

Bhatia, M. L. (1939) : The prostomial glands of the Indian leech, *Hirudinaria granulosa*. *J. Morph.* **64** : 37-46.

——— (1941) : Hirudinaria (Indian Cattle Leech). *Indian Zool. Mem.* **8** : 1-85.

——— (1956) : Extra-ocular photoreceptors in the land-leech *Haemadipsa zeylanica agilis* from Naini Tal, Almora. *Nature* **176** : 420.

——— (1970) : The segmentation of the Ganthobdellid leeches with special reference to the Indian leech *Hirudinaria* and Medicinal leech *Hirudo*. *J. Morph.* **132** : 361-376.

Haeckel, E. (1883) : From the Fauna of British India, Hirudinea, 1927.

Harding, W. A., & Moore, J. P. (1927) : The Fauna of British India—Hirudinea.

Harrison, J. L. (1953) : Sexual behaviour of Land-leeches. *J. Bombay nat. Hist. Soc.* **51** : 954.

Hooker, J. D. (1854-1855) : Himalayan Journals. London, Ist. ed. pp. 107, 167.

Khan, M. M. (1912) : Notes on rearing leeches in Bara Banki District, U.P. *Rec. Indian Mus.* **7** : 206-207.

Kinloch, A. P. (1922) : Leech attacking a snake. *J. Bombay nat. Hist. Soc.* **28** : 557.

Landon, P. (1905) : The opening of Tibet. New York, p. 49.

LESLIE, C. J. (1951) : Mating behaviour of Leeches. *J. Bombay nat. Hist. Soc.* **50** : 422-423.

MANN, K. H. (1962) : Leeches (Hirudinea). Their Structure, Physiology, Ecology, and Embryology. Inter. Ser. Monographs on Pure and Appl. Sci. Zool. Div. 11.

MATTHAI, G. (1921) : Preliminary observations on cocoon formation of common Lahore leech, *Poecilobdella granulosa*. *Proc. Assoc. Soc. Bengal* **16** : 341.

MOORE, J. P. (1927) : Fauna of British India, Hirudinea.

———— (1932) : Land-leeches in the ' Fauna of British India '. Some corrections. *Rec. Indian Mus.* 34 : 1-6.

OKA, A. (1895) : On some New Japanese Land-leeches. *Journ. Coll. Science Imp. Univ.* **8** : 275-306, Pls. XXVIII-XXX.

OKA, A. (1917) : Zoological Results of a Tour in the Far East. Pt. iii. Hirudinea. *Mem. Asiat. Soc. Bengal* **6** : 159-176, pl. vii.

RICHARDSON, L. R. (1942) : Observations on the migratory behaviour of leeches. *Canad. Fld. Nat.* **56** : 67.

SEMPER, C. (1863) : Zeitsch. f. wiss. Zool. xiii, p. 559.

SMYTHIES, B. E. (1953) : Notes and queries on Land-leeches. *J. Bombay nat. Hist. Soc.* **51** : 954.

TENNANT, J. E. (1861) : From the Fauna of British India, Hirudinea, 1927.

WHITMAN, C. O. (1884) : The external morphology of the leech. *Proc. Amer. Acad. Arts Sci.*, **20** : 76.

———— (1886) : Leeches of Japan. *Quart. Journ. Micr. Sci.* **26** : 317.

———— (1888) : Some new facts about the hirudinea. *J. Morph.* **3** : 286.